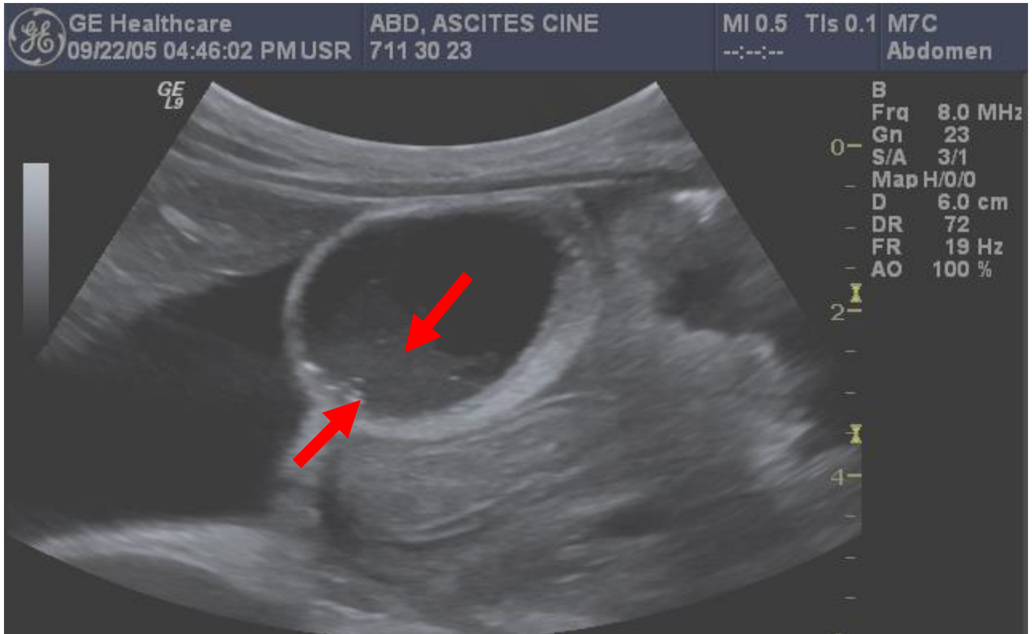
Characterization of Ultrasound Elevation Beamwidth Artefacts for Brachytherapy Needle Insertion

Mohammad Peikari

Advisor:
Dr. Gabor Fichtinger

Laboratory for Percutaneous Surgery
School of Computing, Queen's University, Canada

Motivation



Gall Bladder

(arrow points to false artifact)

- All US-guided procedure suffers from section thickness artifacts
- Appearance of anatomy and localization of surgical tools affected
- Motivating application is the transrectal ultrasound (TRUS) guided prostate brachytherapy

Figure: http://www.gehealthcare.com/c

Achievements

- Nominated for **best master research award** – IEEE Kingston section 2011
- **Journal of Medical Physics** 2012 (ISI impact factor = 3.25)
- Medical Image Computing and Computer Assisted Intervention (**MICCAI**) conference 2011 (peer reviewed conference proceedings)
- International Society for Optics and Photonics (**SPIE**) 2011 (nominated for **best student paper award**)
- Patented a variation of the presented device by other members of the group

Prostate Cancer

- Second leading cause of cancer related death
- Treatment optic
  - Prostatectom
  - external beam radiati
  - Brachyther
- Potential advantages of brachy

  - Outpatient treatment
  - Comparable to the other treatment options
  - Ability to target tumor and avoid healthy tissues
- Potential disadvantages of brachytherapy:
  - Side effects may vary
  - Highest quality is hard to achieve

Prostate Brachytherapy

- Permanent implantation of radioactive seeds under live ultrasound (US) guidance

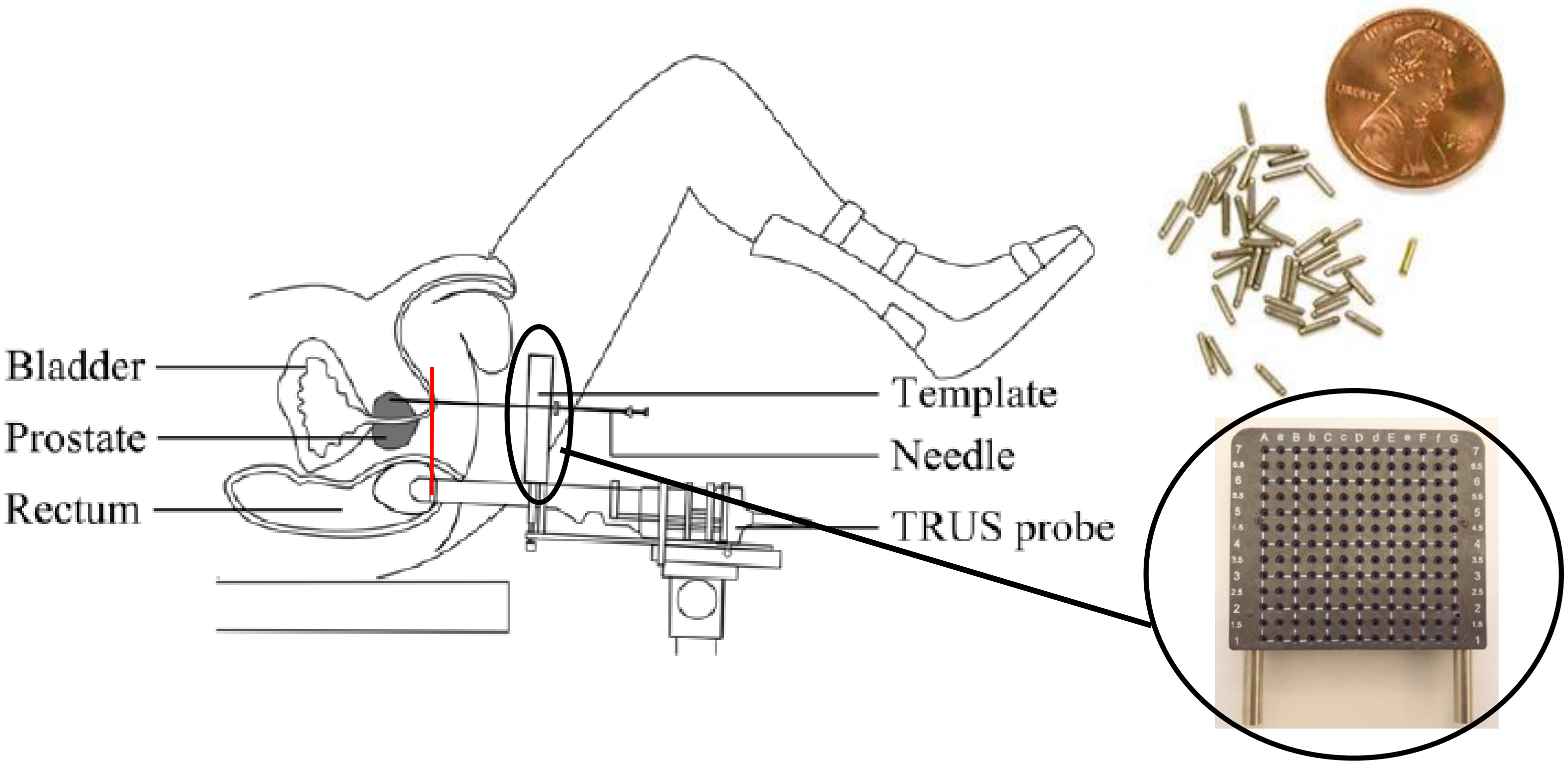
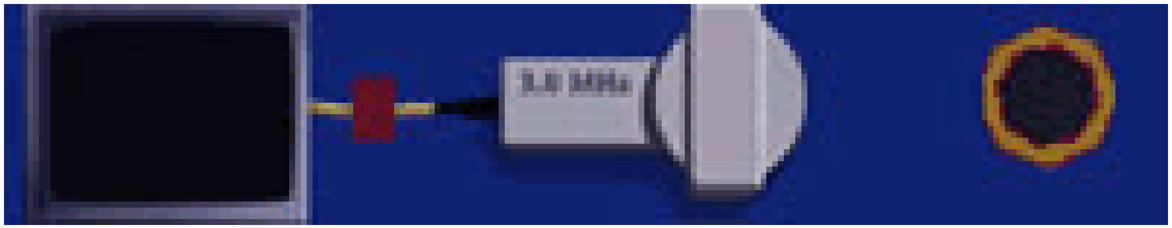


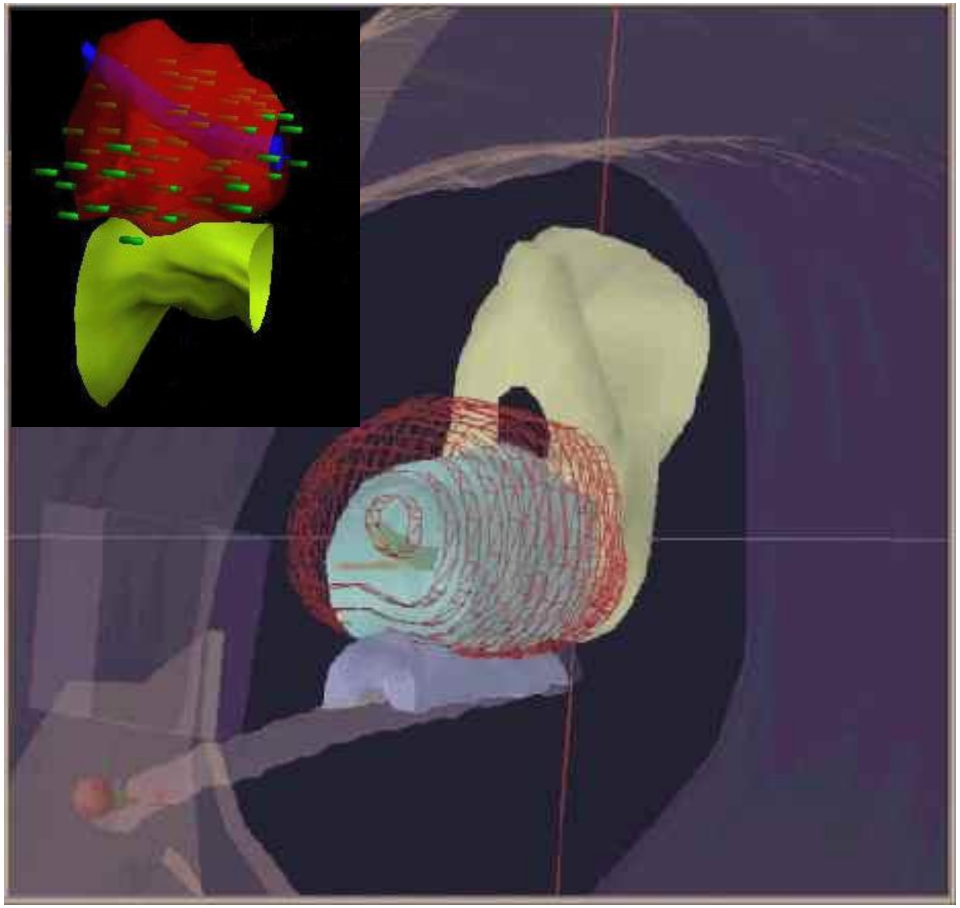
Figure credited to C. Chao from Perk l

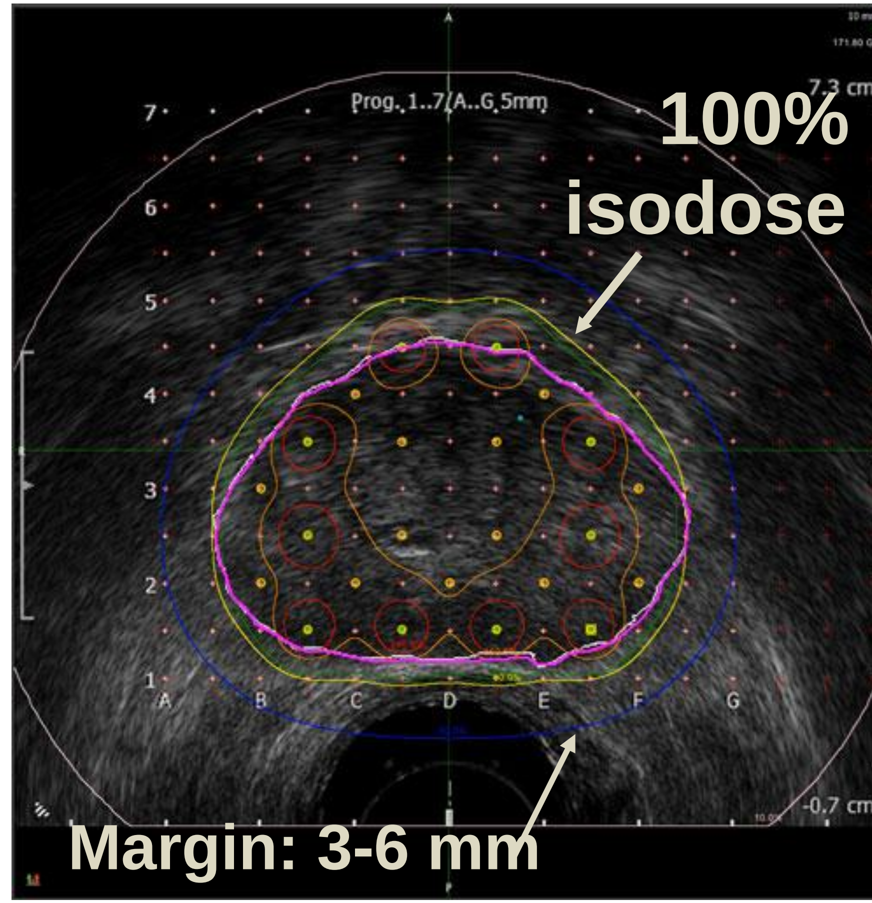
Ultrasound



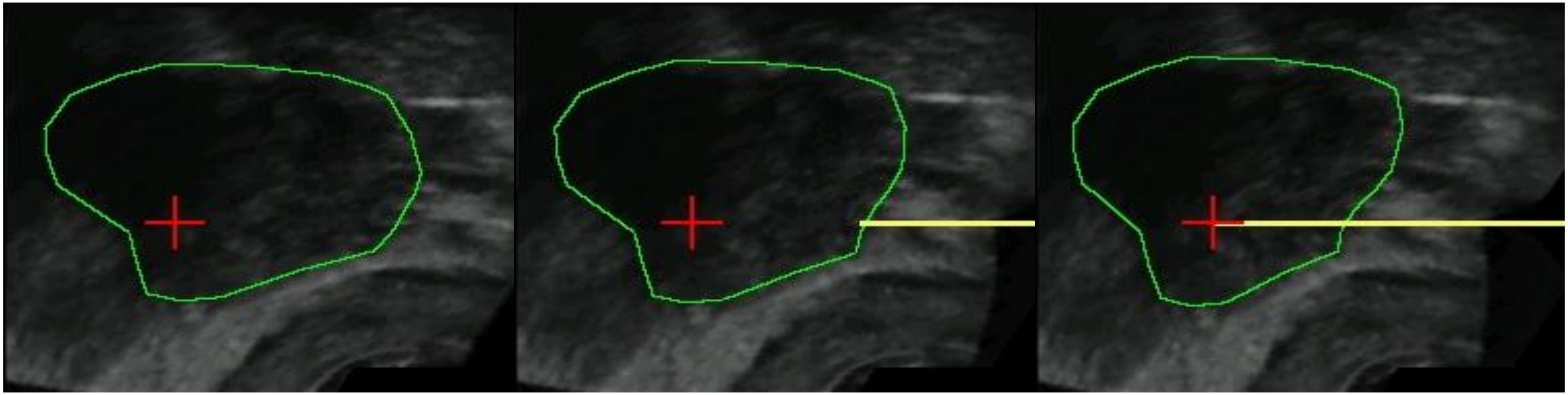
www.en.wikibooks.org and http://www.frca.co.u

Treatment Planning





Ultrasound Guided Needle Insertion



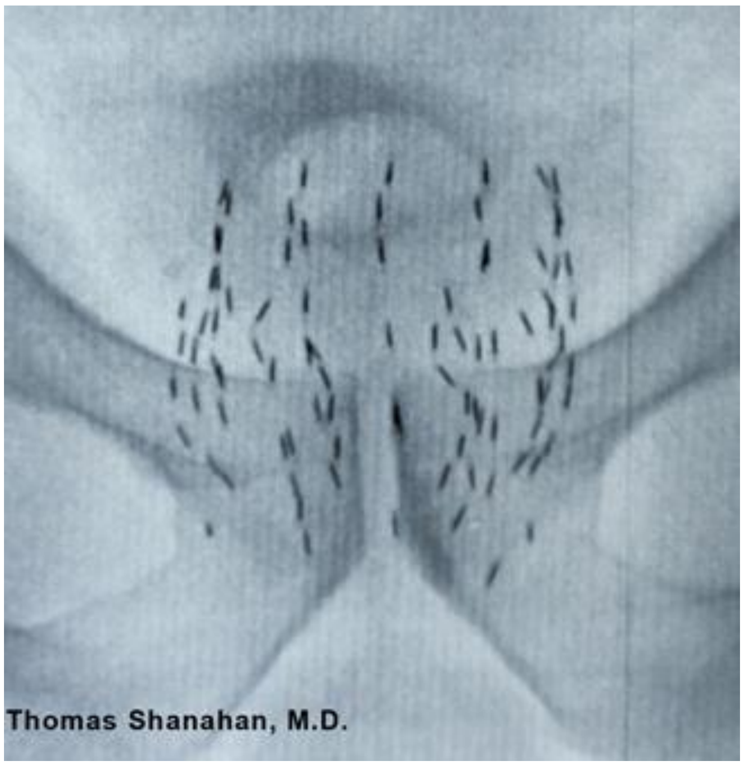
1-Postate with target implant location

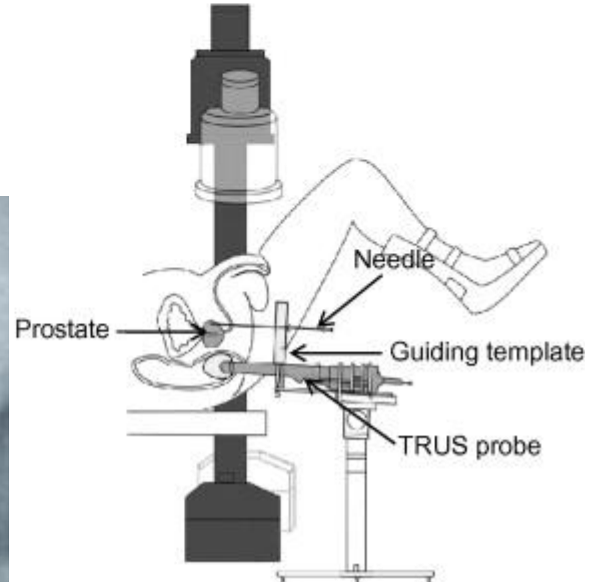
2-Needle insertion

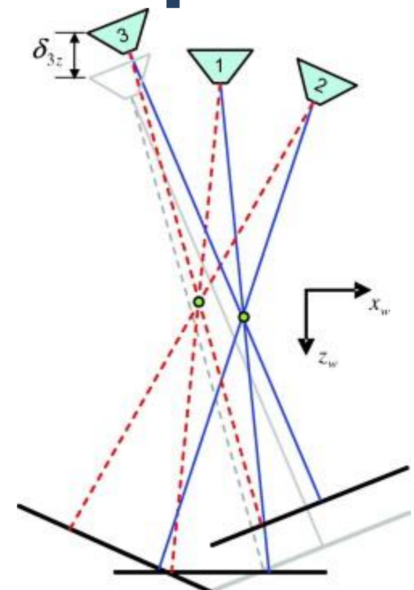
3-Needle reaches the target

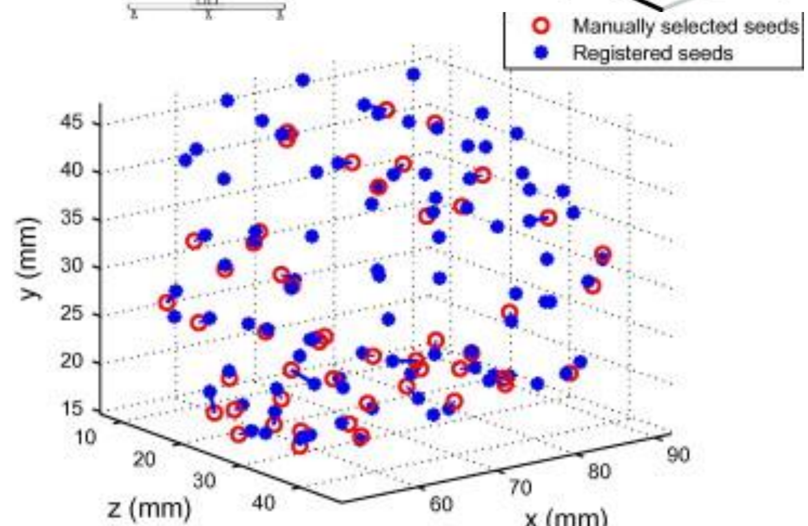
http://www.eecs.berkeley.ed

Treatment Validation and Plan Update



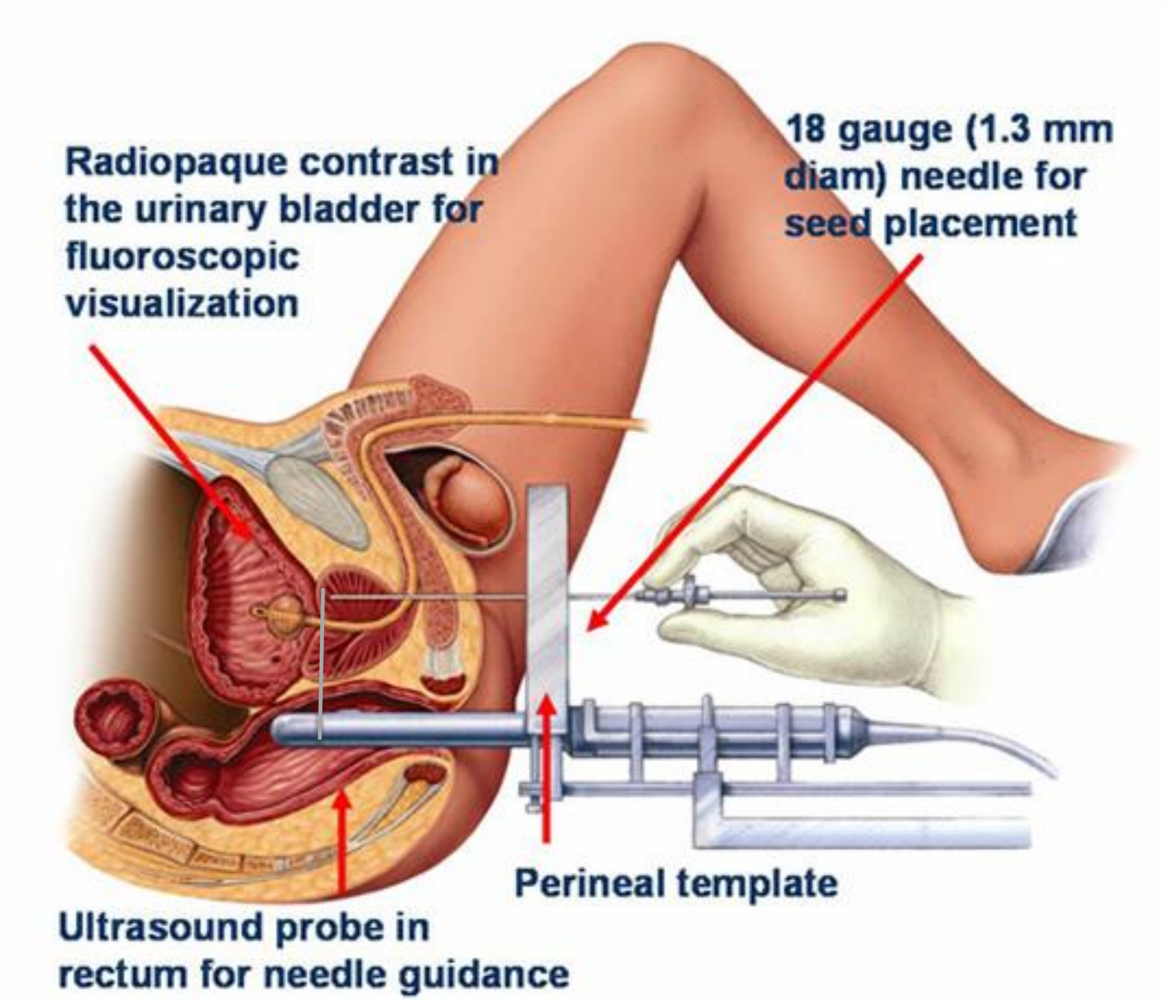






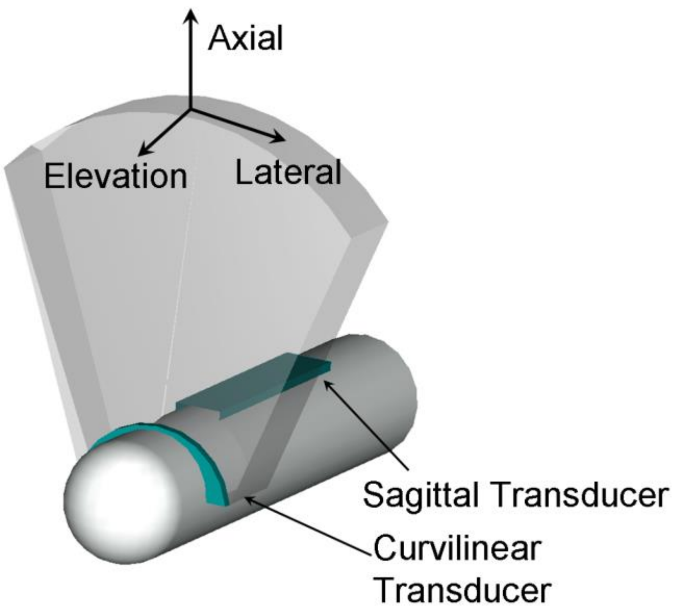
E. Dehghan et al. "Prostate Implant Reconstruction from C-arm Images with Motion-Compensated Tomosynthesis",*Medical Physics*, Vol. 38(10), pp. 5290 – 5302, 2011.

Procedure



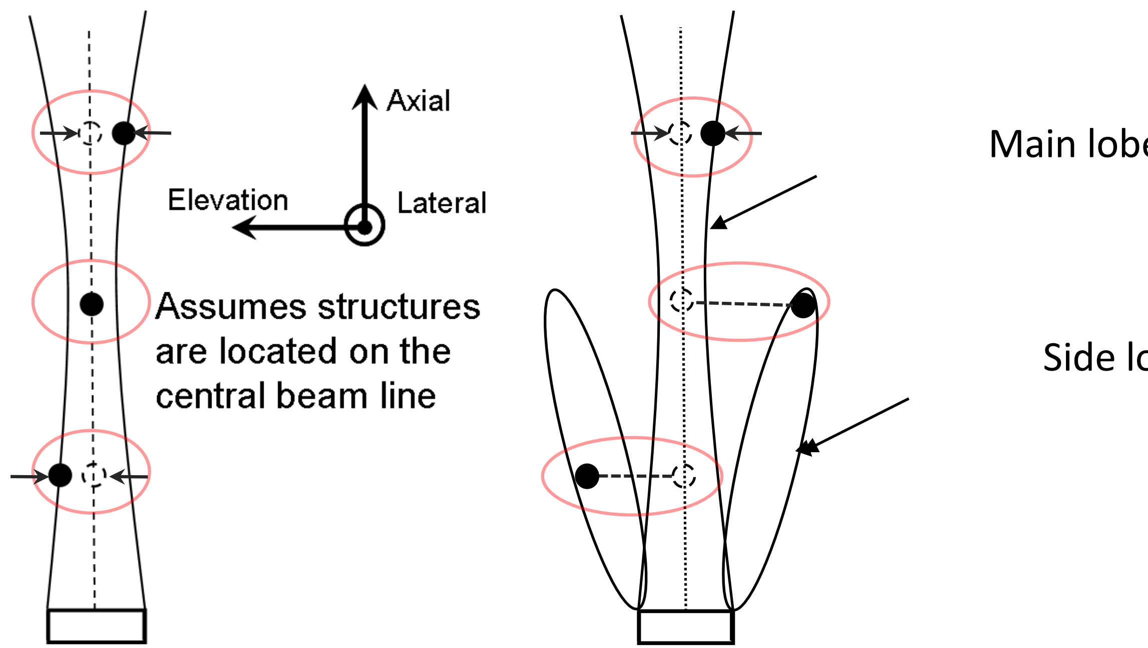
http://www.prostatebrachytherapyinfo.net/PCT21.html

Section Thickness Artifacts in TRUS



a) Main beam thickness

b) Side lobe energies



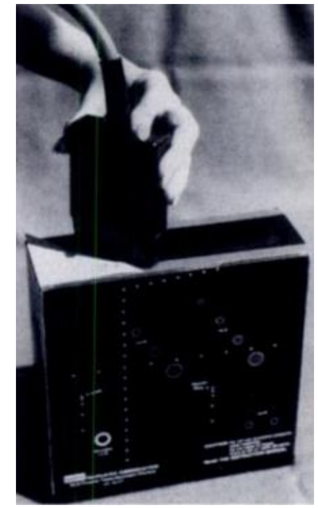
Objectives

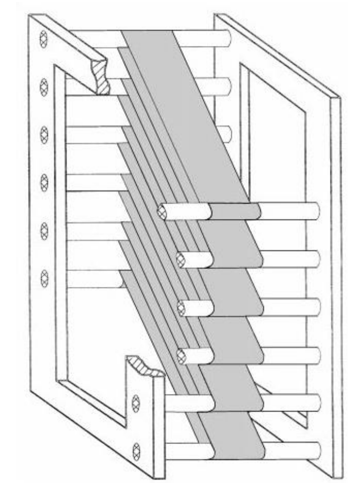
- Characterization the ultrasound elevation beamwidth
- Generate US beam profile
- Compare main beam thickness and side lobe artifacts
- Measure needle tip localization offsets
- Recommendations to reduce the effects of these artifacts

Prior Work on Beamwidth Artifacts

- *Goldstein* (*Ultrasound, 1981*)
- *Skolnick* (*Radiology, 1991*)
  - Compared scan plane and section-thicknesses
  - Used an inclined surface and a phantom with multiple filaments 1cm apart in a vertical row
  - Difference compared to proposed method: Needs segmentation of the filaments
- *Richard* (*Radiology, 1999*)
  - Used several inclined surfaces located successively below each other in a phantom
  - Difference compared to proposed method:

    more complex phantom, results only at specific positions

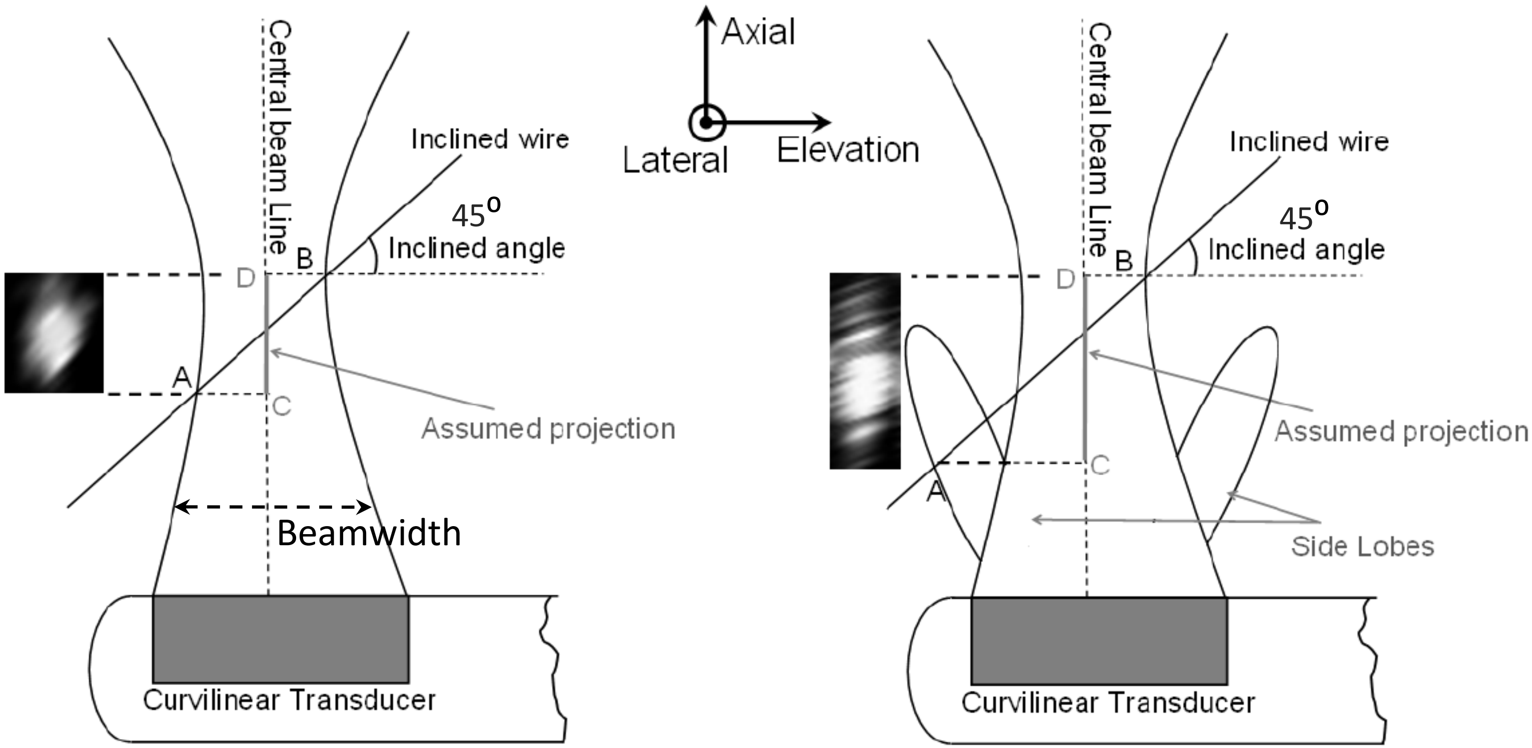




Prior Work on Side Lobe Artifacts

- *Laing* (*Radiology,* 1982)
  - Illustrated the genesis of side lobe artifacts
  - Employed round plastic container filled with de-gassed water and a sponge
  - Compared the effects of main and side lobe artifacts
- *Barthez* (*Radiology and Ultrasound, 1997*)
  - Reproduced the artifacts using metallic wires and wooden tongue depressor
  - Employed all sorts of US transducer
  - Shape and intensity varied with US transducer type

Beamwidth Measurement



Main beam thickness

Main and side lobe beams thickne

- CD≈Ultrasound beamwith
- The US beamwidth is larger when side lobe energies present around the main lobe